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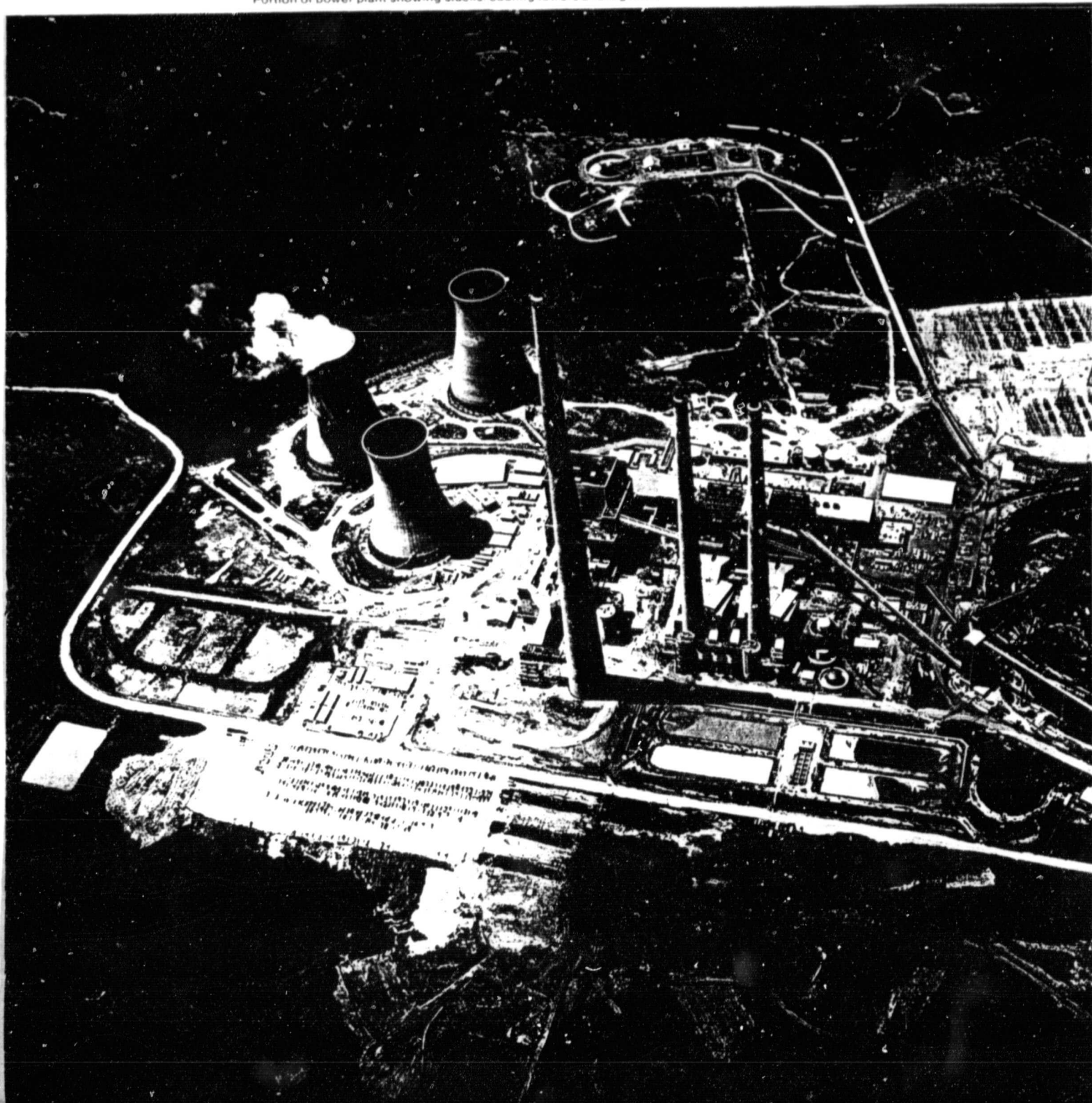
Office of Research and Development
Washington, D.C. 20460



Seeing Is Believing

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Portion of power plant showing stacks, cooling towers and lagoons



E83-10223



CENTER FOR REMOTE SENSING AND CARTOGRAPHY

CR-170081

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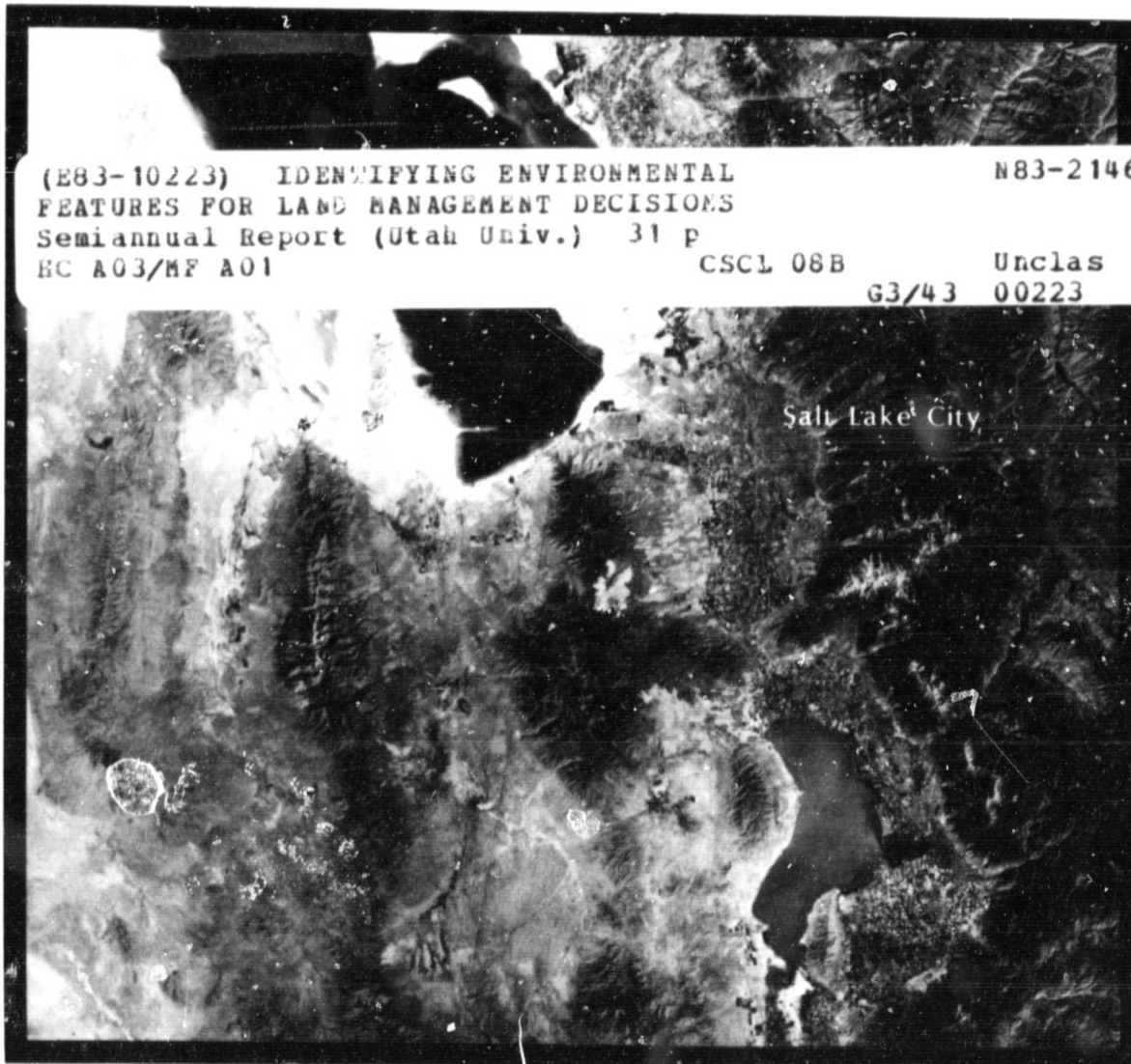
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Semiannual Report (Utah Univ.) 31 p
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UNIVERSITY OF UTAH RESEARCH INSTITUTE

Salt Lake City

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SEMI-ANNUAL REPORT
IDENTIFYING ENVIRONMENTAL FEATURES
FOR LAND MANAGEMENT DECISIONS
NASA Grant NAGW-95
March 11, 1982



Prepared for
National Aeronautics and Space Administration

by
Center for Remote Sensing and Cartography
Applied Technology Division
University of Utah Research Institute
Salt Lake City, Utah

INTRODUCTION

This semi-annual report outlines the major accomplishments of the Center for Remote Sensing and Cartography (CRSC) since the annual report was submitted in October 1982. The past few months have been characterized by important progress in digital processing techniques, completion of a project involving integrated remote sensing and environmental analysis, and interesting developments for new and continuing projects. Our computing strength is stronger than ever; we continue to rely primarily on the Earth Sciences Laboratory's Prime computer, but nearly all of the troubleshooting and software development is done in-house.

CRSC FOCUS

CRSC continues its activity in dealing with an array of environmental and resource problems in the Intermountain Region. Our effort continues to focus on specific needs defined by the agency. More and more we are conscious of the value of dealing with each project as a team effort between CRSC specialists and agency resource specialists. In this way, our credibility is increased and the products are more effective.

This approach demands that CRSC remain oriented to alpine environments and arid/semiarid environments, the dominant landscapes of the region. This means that we must continue to be attuned to a variety of environmental systems, including vegetation, soil, hydrology, geomorphology, and agriculture. In every project, the interrelatedness of the various systems is not only evident, but significant in the problem-solving approach.

On the question of technical specialization, CRSC continues to pursue a course of merging remote sensing with GIS analysis. Ancillary data are vital in their own right as a decision-making tool, and also as a key to refinement in the classification of remote sensing data. Thus, we are moving toward an integrated procedure, invoking digital ancillary data and remote sensing data at appropriate levels through the resource analysis stage to the decision stage.

Folded into this integrated procedure is the necessary field investigation, photo interpretation, map and archival data analysis to provide the resource manager with the comprehensive documentation necessary for sound decisions.

We do not intend to usurp, but to augment, the professional manager's role, filling those steps he is otherwise unable to fill. Our staff is well trained in field, lab, and library procedures in resource analysis as well as in remote sensing per se. Recently, we have been called on to perform such comprehensive evaluation, e.g. Parker Mountain study and Humboldt River study for Nevada Fish and Game. In these broad studies, as well as in projects more restricted to techniques of remote sensing, CRSC is ready to bring in the agency professional to the fullest extent. We wish to have agency personnel fully aware of the capabilities and limitations of the role of remote sensing and GIS analysis, so that their professional judgement is not abdicated to our lab or to the "machine."

OUTREACH

CRSC's latest annual report summarizes outreach activities through October 1982. Since that time, outreach activities might be grouped as

(a) professional meetings, (b) promotional visits, and (c) proposals. The outreach items refer to activities involving CRSC's director, Merrill K. Ridd; manager, Richard A. Jaynes; and remote sensing specialist, John A. Merola.

Professional Meetings

1. Utah Association of Geographers. Ridd presented paper on remote sensing studies of Great Salt Lake. November 1982.
2. ERIM Symposium at Fort Worth on remote sensing and geological exploration. Ridd attended. December 1982.
3. Utah meeting of ACSM-ASP. Jaynes and Ridd presented summary of CRSC projects. December 1982.
4. Bear River Resource and Conservation District meeting in Logan. Ridd appointed to committee to create pilot project for comprehensive soil and water management planning, based on remote sensing and GIS. December 1982.
5. Meeting of Environmental Health Division. Ridd invited to present summary of CRSC remote sensing activity. January 1983.
6. Working session of Caribou National Forest, Idaho Fish and Game, etc. Merola presented aspen succession study. March 1983.

Promotional Visits

1. EPA, Las Vegas. Ridd visits. November 1982.
2. Nevada Fish and Game. Jaynes and Ridd meet agency specialists in Elko to outline project. December 1982.
3. CRSC staff and EPA personnel summarize remote sensing and discuss ENVIROPOD applications with 25 invited state and federal agency leaders in CRSC's conference room. December 1982.
4. Resource Development Coordinating Committee (Utah). Ridd supports presentation of ENVIROPOD applications to 40 state and federal agency environmental leaders. January 1983.
5. A dozen state, federal, and local agencies are visited by CRSC staff. November 1982 to March 1983.
6. Soil Conservation Service calls CRSC and proposes a funded remote sensing analysis of pinyon-juniper environments relative to erosion dynamics. September-December 1982.

Proposals

1. U.S. Army Engineer Topographic Laboratory invited CRSC to provide a sole-source project outline for a study in Nevada. The project was approved administratively, but as yet unfunded.
2. Mexican government agency CONAZA called to renew a proposal prepared last year, but left unfunded due to devaluation of the peso.
3. CRSC staff has prepared a proposal to the National Science Foundation for research on remote sensing application to desertification assessment and monitoring.
4. A proposal was prepared and submitted to the Department of Defense to obtain a state-of-the-art digital processing hardware/software system. In the proposal, we outlined our need for color display and frame grabber capabilities in performing projects we have been discussing with the U.S. Army.

PROJECTS COMPLETED

Two projects have been completed since our annual report was prepared in October 1982. A summary of CRSC projects to date may be found in Exhibit A.

Parker Mountain Rangeland Inventory and Analysis

CRSC's recent efforts in completing an inventory and analysis of rangeland resources on the 45,000 acre Parker Mountain state land block promise to be influential in directing the course of future resource management of that area. The study's technical report (CRSC Report 82-6) describes the integrated use of CIR photo interpretation, Landsat MSS digital data, ancillary spatial information (e.g., soils, geology, precipitation), and field observations in producing rangeland cover maps. In addition, the technical report includes specific recommendations regarding how the maps should be used in planning field investigations. Recommendations regarding vegetation modifications to increase livestock and wildlife carrying capacity, and grazing management strategies are also included. A major conclusion in the study is that there is a need to prepare a revised management plan based on the information gathered in our study. A recent letter

from the Parker Mountain range manager, which is attached as Exhibit B, indicates that the study will be a primary element in planning range management activities in the near future. An immediate impact of the study will be its use in locating study sites for field investigations planned for the 1983 summer season by the Division of State Lands and Forestry.

The Parker Mountain study posed some interesting technical challenges. For both photo interpretation and Landsat portions of the analysis, various combinations of vegetation cover, surface geology, and slope aspect often led to the confusion of a short growth form of mountain big sagebrush with black sagebrush. In addition, some silver sagebrush areas were spectrally and visually similar to big sagebrush vegetation cover. Field observations and ancillary data provided solutions to most sources of interpretive confusion.

Available geology, soils, and precipitation maps were used to sort out areas of confusion on the CIR photography. The map overlay from photo interpretation was also prepared with reference to print maps developed from Landsat MSS data. The resulting map overlay has a high degree of interpretive and spatial accuracy. The following major vegetation cover types were identified: aspen forest; tall growth form mountain big sagebrush; short growth form mountain big sagebrush; black sagebrush; mountain silver sagebrush; and wetland.

Initial assessment of Landsat MSS mapping accuracy showed an unacceptable level of confusion between the several sagebrush types in different portions of the study area; we estimate that the initial overall map accuracy with six major cover types was less than 65%. It was found that this confusion could largely be corrected by introducing ancillary data. Boundaries from geology, soils, and precipitation maps, as well as field observations, were digitized and pixel classes were adjusted according to

the location of pixels with particular spectral signatures with respect to such boundaries. The resulting map, with six major cover classes, has an overall accuracy of 89%. Overall accuracy was 74% when these six classes were expanded to 20 classes.

This project has permitted a close evaluation of the relative merits of mapping rangeland resources from CIR photo interpretation and from MSS digital data. It was concluded that best results are obtained when both approaches are used in tandem; each approach has certain inherent disadvantages which are to a large extent corrected by utilizing the other approach.

The completion of the study on Parker Mountain represents a significant achievement for CRSC; it will be used as a model for future studies to integrate remote sensing data with environmental information to develop comprehensive resource management plans. The State of Utah currently has a number of other land blocks which are also in need of detailed inventories and analyses. In addition, the state is presently making plans with its "Project BOLD" to accomplish further blocking-up of state-owned tracts. We hope to have the opportunity to perform similar studies on other state land blocks in the future.

Using Multitemporal Data to Study Aspen Succession Stages

In our study for the Forest Service in northern Utah, we have been quite successful in separating aspen-to-conifer succession stages into six classes: stable aspen; early seral; early to mid-seral; mid to late seral; late seral; and conifer forest. These classes have been logically developed from the analysis of field data collected from a helicopter for 156 study plots of aspen and aspen-conifer forest mixes, and for 36 aerial photo plots for the conifer class. The development of these classes is very important for further use of this mapping technique, as we have established the type

of breakdown of seral aspen one can expect in any mapping project using MSS data.

By taking a second date (October, after leaf-fall) we have been able to pick out some early seral stage areas (where young conifer is just beginning to invade the understory of aspen). The second date also helped to avoid confusion between late seral and mid-seral classes, to result in an overall accuracy of 72% for our verification plots.

This achievement has very wide-spread application throughout the Rocky Mountains where changing aspen (being crowded out by conifer) is a great concern to managers. As conifer invades, water yields go down, as do wildlife habitat and other values. A recent dissertation at BYU, by a Forest Service resource specialist, estimates that there is a loss of \$14 per acre, per year in every acre we let convert to conifer, from water values. The technical report for our project is presently in draft form and will be completed within the next few weeks. A visual abstract is also being prepared and will be forwarded as soon as it is completed.

We are planning to take our results to the National Forests and to the State, who are very concerned about water and game losses from aspen-to-conifer succession. As we can stratify the various stages in the forest, they will have ready access to key information for decision-making. This has been an issue for a long time.

PROJECTS UNDERWAY

Salt Lake County Land Use Study

This is a key study in fostering our working relationship with Utah's Department of Natural Resources and Energy. A rather thorough outline of the study, as well as the study plan, were presented in our October 1982 annual

report. Since that time, we have been implementing the techniques outlined there. A few recent developments are worth noting, however.

We have been able to acquire CIR aerial photography from the Bureau of Reclamation; the photography was obtained in late June 1982 when Thematic Mapper Simulator (TMS) data was acquired for the study area. The photography will allow us to update our map overlays to show land use as of the 1982 growing season. We have also acquired the TMS data within the past couple of weeks, and anticipate comparing maps prepared from TMS data with maps from photo interpretation and Landsat MSS data.

This study has provided an opportunity for our first application of an ELAS software program which automatically computes an error matrix for a given classification of digital data. We anticipate that this program will add valuable input to the process of calibrating a given Landsat classification to ground truth, and in choosing the best classification approach where several possibilities exist. In this study, we are looking at classifications of raw data, filtered data, and four-band data which has been reduced to two principal components and filtered.

A second aspect of digital processing is the use of non-classified digital data to detect urban change. Initial results of using simple single-band differencing techniques has led us to explore band ratios to detect change. We anticipate that the results from our digital applications will be available a couple of months after our maps from photo interpretation are completed.

Wasatch-Cache Riparian Study

Some recent modifications to the Prime computing system should enable us to read DMA digital terrain tapes. The inability to read the tapes has

delayed our efforts to resolve spectral confusion between riparian and non-riparian habitat in portions of the study area. We have recently reassessed the project with the Forest Service and we now plan to move ahead with this study this spring, and complete it by fall.

EPA ENVIROPOD

After several months of negotiation, a three-way Memorandum of Understanding has been signed among UURI, the State of Utah, and EPA-Denver Region. The objective is to make the ENVIROPOD, owned by EPA, available at no cost to the State of Utah (and other interested agencies) to engage in job specific low-altitude photography. EPA has designated CRSC as the technical hub in the arrangement. (See Exhibit C.) CRSC will be responsible for handling film and mounting of the pod, etc. CRSC will also design flight specifications in cooperation with the requesting agency. CRSC will also coordinate inter-communications among agencies to maximize use and efficiency of the instrument.

CRSC will extend its outreach significantly through the promotion of the ENVIROPOD. We anticipate three kinds of benefits from this activity:

- (1) CRSC will make itself available to provide interpretation of the acquired photography, at the agency's request, and for a reasonable cost.
- (2) CRSC will integrate current ENVIROPOD photography into the anticipated regional training sessions/workshops planned for this summer through the state and region.
- (3) CRSC will continually promote its other remote sensing capabilities through the on-going interaction with the agencies relative to ENVIROPOD use.

We have considered this ENVIROPOD activity to be a very appropriate use of NASA funds as an effective outreach tool. We also hope to be able to generate a few direct dollars, through a graduate internship and through

selling some photo interpretation skills. We also hope for a payoff in terms of increasing our visibility and credibility in the non-digital/non-satellite domain. Finally, we hope for a larger long term payoff in promoting applications in the digital satellite data/GIS/environmental analysis domain.

Humboldt River Riparian Habitat

The Nevada Department of Wildlife recently contacted CRSC regarding the need to obtain accurate and up-to-date maps of riparian habitat along a segment of the Humboldt River in north-central Nevada. Wildlife habitat is significantly affected by various activities along the river: channelization, and spraying or burning of willow areas. As outlined in the study plan, attached as Exhibit D, the primary objective of the study is to prepare 1:24,000 scale topographic map overlays of riparian habitat and other significant features for a stretch of river which flows through portions of land represented on eight U.S.G.S. quadrangles. This mapping project will utilize CIR photography (both high and low altitude) as well as field observations. For one selected study site, we will explore the extent to which environmental changes due to management activities may be monitored over time.

The primary purpose of the study is to provide a spatially-oriented information base for wildlife population and habitat management for this particular riparian zone. This information base will be a key element in the development of Department policies and public awareness regarding proposals for and actions to carry out river channelization and phreatophyte control. The study will also demonstrate the limits of using available aerial photography for obtaining needed riparian habitat information.

RECENT TECHNICAL DEVELOPMENTS

In the follow-on proposal submitted in March 1982, we mentioned five key areas of focus for anticipated technical developments. A brief discussion of progress since that time in each of these five areas is presented below. In addition, other technical developments have been accomplished, arising out of the need for either new kinds of information or greater efficiency in obtaining standard analytical information.

Map Digitizing and GIS Analysis

CRSC has been digitizing maps on the UURI/ESL PRIME system for several months. The digitized maps are then used in various types of GIS analyses. The ELAS program package allows us considerable flexibility in using the digitized maps for post-classification improvement of MSS digital data. For example, our analysis of rangeland in the Parker Mountain study was greatly improved using this technique. Polygons derived from soil and geology maps were digitized for stratification of the classification. Selected contour lines digitized from topographic maps also added significantly to the classification accuracy. Combined, the digitized entry of soil, geology, and elevation data produced a classification accuracy which was over 21% more accurate than the maps prepared from spectral data alone. A new computer program was written to insert the polygons back into the map after changes were made.

ELAS has also allowed us to use a very complicated GIS analysis for the combination of two dates of MSS data in the Aspen Succession study. The analysis was complicated in the sense that there were many possible changes that could have been made to any one pixel provided that it passed one or a combination of seven different tests. We are very pleased with the results obtained thus far.

Digital Terrain Data Integration

CRSC has been working on this very important technique. We have experienced a substantial setback due to the limitations of the operating system of the UURI/ESL PRIME computer. This occurred as a result of the inability of the operating system to read the variable length records of the NCIC digital terrain data. This problem has been resolved with the installation of a revised operating system which took place last week.

Principal Components Analysis

The use of discriminant analysis, based on principal components and cluster analyses of MSS signatures, continues to be a key element in achieving good results from the unsupervised approach to Landsat data analysis. The procedure has been recently streamlined for further automation and ease of operation, to allow its use by a novice, if need be.

We have also been investigating the use of principal components of raw pixel data prior to classification. We have no conclusive results as yet, but it does appear the routine in the ELAS package is weak and a new and stronger routine is needed.

We are also investigating the application of principal components as a type of band ratioing for use in change detection for the urban areas of Salt Lake County.

Albedo and Band Ratioing

Albedo ratioing has been developed and tested to our satisfaction. As yet, we have not found a suitable opportunity to apply it.

Band ratioing is being used in the Salt Lake County study to aid in detection of urban change. We have tested procedures in the literature and

found them to be inadequate for our needs. Consequently, we are developing new procedures using band ratioing to find the best technique for multi-temporal urban change detection.

Multidate Registration

This technique has been tested and applied, successfully, in the Aspen Succession study. For that study, multidate registration was used to combine the information from two dates to increase forest mapping accuracy.

We are also using it for urban change detection in the Salt Lake County study. In this study, the multidate registration is critical to the change detection and future updating of the maps.

Other Technical Developments

CRSC has recently been implementing a software module in ELAS called "Accuracy of Classification Table Builder" (ACTB). This program creates an error matrix by comparing the results of a classification with "ground truth" or verification data. The program outputs a table that shows class frequencies, percentages, percent correct, omission errors, and commission errors by comparison between the digitized verification data and the classified data.

We have been using error matrices for sometime now, to describe map accuracies, but we constructed the matrices by hand and only for the final maps. The program ACTB will allow us to speed up and improve the process of developing and comparing classification algorithms for a particular mapping project. The improvement is through automation of the process of combining signatures or trying different pre- and post-classification techniques and assessing the results. ACTB gives us the needed information

quickly which provides an objective means to decide which classification technique is best. ACTB is also an excellent means to aid in fine-tuning each classification option prior to selecting the best classification approach for a particular project.

We have an ongoing interest in exploring new methods to make classification improvements. To this end, we have been using and developing filtering and texture routines. Recently, we developed and tested a texture routine that uses the standard deviation of a moving window to assign that value to the center pixel of the window.

We have also continued our research into the utility of filtering Landsat data in the Parker Mountain, Salt Lake County, and Aspen Succession studies.

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Table 1. CRSC Projects Supported in Whole or Part by NASA Grants NSG-7226 and NAGW-95

Project Short Title	CRSC Report	Agency/ies	Agency Support	Completed	Project Impact
PROJECTS COMPLETED					
North Ogden Hazards to Urban Development	78-1	Weber County, No. Ogden City, Pleasant View	Limited in Kind	May 1978	Adopted for Sensitive Area Overlay Zone Ordinance.
Irrigation Detection by Satellite, Iron Co.	79-1	Utah Div. of Water Rights	Limited in Kind	April 1978	Proven effective. Led to ground water study.
Price River Basin Rangeland Response to Summer Rain	79-2	U.S. Bureau of Land Management	Limited in Kind	May 1979	Proven effective but demands real-time data for application.
Korean Land Use II	79-3	Republic of Korea	\$102,000	Aug. 1979	NASA funding helped develop software; technical development.
Snowpack/Runoff Correlation	Experimental	Utah Div. of Water Resources Soil Cons. Serv.	Limited	--	High correlations shown. Tabled until near real-time data is available.
Guayule Inventory I: Contrast Enhancement	80-1	Mexican Government	\$90,000	Jan. 1980	NASA funding helped perfect computer enhancement.
Uinta Basin Wetland/Land Use	80-2	Utah Div. of Water Resources Soil Cons. Serv.	\$10,000 \$25,000	Dec. 1980	Wetland management, water allocation and management, agriculture resource planning.
Snow Cover/Mule Deer	80-3	Utah Div. of Wildlife Res.	Limited in Kind	July 1980	Landsat utility, tabled pending agency studies.
MX Draft EIS Review	81-1	Utah Governor's Office	ca. \$2,000	April 1981	Used by Governor for MX policy and comment.
Guayule Inventory II: Statistical Classification Routines	81-2	Mexican Government	\$100,000	Feb. 1981	NASA funding helped develop classification routines.
Farmington Bay Shoreline	81-3	Utah Div. of Wildlife Res. Great Salt Board	In Kind Minimal	April 1981	Deterred proposed project which would have damaged waterfowl habitat.
Irrigation Detection, Iron County II	81-4	Utah Div. of Water Rights	Minimal	May 1981	Proven effective; led to Bear River Study; leading to prosecution.
Davis County Foothill Development	81-5	Davis County Planning Comm. Four Corners Regional Comm. EPA 208 Weber-Davis Several State Agencies Seven municipalities	In Kind \$63,000 \$18,000 In Kind In Kind	May 1981	Being reviewed for adoption as the guideline for urban development control.

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Table 1 (cont.)

CRSC Projects Supported in Whole or Part by NASA Grants NSG-7226 and NAGW-95.

<u>Project Short Title</u>	<u>CRSC Report</u>	<u>Agency/ies</u>	<u>Agency Support</u>	<u>Completed/ Anticipated Completion</u>	<u>Project Impact</u>
Sevier River Basin Wetland; Land Use	81-6	Soil Conservation Service	\$23,000	Oct. 1981	Basic information for wetland mgt. and water allocation.
Farmington Bay Wildlife Habitat	82-1	Utah Division Wildlife Resources	In Kind	Mar. 1982	Likely to influence diking, revegetation, wetland permits.
Bear River Range Aspen Habitat	82-2	U.S. Forest Service, NSF	\$11,000	Mar. 1982	Statistical signature refinement. Lead to riparian study.
Bear River Basin Irrigation Land Inventory	82-3	Bear River Commission	\$ 9,000	Apr. 1982	Will be basis for water allocation between states.
Aspen/Aspen-Conifer Detection	82-4	Intermountain Forest & Range Experiment Station	\$ 7,499	June 1982	Improve inventory techniques and habitat analysis.
San Luis Potosi Rangeland Inventory	82-5	Mexican Government	\$52,000	Feb. 1982	NASA funding helped develop technical expertise for digital analysis.
Parker Mountain Rangeland	82-6	Utah Division of State Lands and Forestry	\$ 4,541	Dec. 1982	Basic information and recommendations for revegetation and range management.
Multitemporal Aspen/Conifer Detection	83-1	Intermountain Forest & Range Experiment Station	In Kind	Mar. 1983	Refinement of techniques for forest inventories.
Land Use Inventory of Salt Lake Co.	83-2	Utah Division of Water Resources	\$17,248	Apr. 1983	Data for hydrologic modeling and change detection.
Wasatch-Cache Riparian Vegetation	83-	U.S. Forest Service	\$ 3,500	Sep. 1983	Basic information for wetland and wildlife management.
Humboldt River Riparian Habitat	83-	Nevada Dept. of Wildlife	\$ 8,344	Oct. 1983	Information base for developing wildlife habitat policies and technique development for habitat monitoring.
EPA-Enviropod	84-	U.S. E.P.A. and various state agencies	In Kind	Apr. 1984	Planning and acquisition of Enviropod photography, and evaluation of results.



STATE OF UTAH
NATURAL RESOURCES & ENERGY
State Lands & Forestry

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Exhibit B

Scott M. Matheson, Governor
Temple A. Reynolds, Executive Director
Ralph A. Miles, Division Director

Southwestern Region • 130 N. Main • P.O. Box 652 • Richfield, UT 84701 • 801-896-6494

March 3, 1983

Richard A. Jaynes
University of Utah Research Institute
UURI
Center for Remote Sensing and Cartography
420 Chipeta Way, Suite 190
Salt Lake City, Utah 84108-1295

Dear Richard:

I have received and reviewed the final report and maps that you sent regarding the inventory and analysis of rangeland resources on Parker Mountain. The report and maps at first review seem to be very concise and accurate. I feel that this information will be of great benefit to us in planning our vegetation inventory this summer as well as planning and implementing any future range improvement projects or grazing management plans.

With this information we should have a good foundation to build a proper range management plan for the entire block.

Sincerely,

Louis Brown
LOUIS BROWN
LAND SPECIALIST

LB:can

MEMORANDUM OF UNDERSTANDING
AMONG
THE STATE OF UTAH,
THE U.S. ENVIRONMENTAL PROTECTION AGENCY,
AND
THE CENTER FOR REMOTE SENSING AND CARTOGRAPHY

BACKGROUND

The Environmental Protection Agency (EPA) is responsible for monitoring systems research relative to the detection and monitoring of environmental contaminants. In recognition of the vast geographic area or areas that must be addressed by national, regional and state monitoring programs, the EPA has encouraged the use of aircraft and satellite data acquisition systems to obtain both synoptic and site-specific environmental data.

To complement more advanced airborne data acquisition systems, the EPA's Office of Research and Development has developed a low cost, readily deployable, overhead monitoring system, known as the ENVIROPOD, which is capable of acquiring high resolution aerial photoimagery in oblique and vertical modes. The technologies associated with this system enhance the capabilities of the regions and participating state agencies in the area of emergency response, compliance, resource evaluation, monitoring and planning. The ENVIROPOD has been evaluated at both the research and operational levels in EPA.

It is the objective of this agreement to make available to the State of Utah, and interested cooperating agencies, overhead monitoring technology on a demonstration basis for a period not to exceed one year. It is understood that the State will provide aircraft coordination through the State Planning Coordinator's Office (SPCO), and that individuals acquiring or requesting aerial photography will be responsible for the cost of services provided by the aircraft and related mission activities. Management and operations of the system will be provided by the Center for Remote Sensing and Cartography (CRSC), University of Utah Research Institute (UURI).

PURPOSE

To establish a program for demonstrating the benefits the State and other agencies can derive from in-house overhead monitoring capabilities and to:

- (1) Determine whether or not such a program can materially improve programs for control and assessment of the environment.
- (2) Attain a measurement of the cost-versus-benefits of such a program and identify how the costs can be defrayed.

SCOPE OF WORK

1. EPA's Environmental Monitoring Systems Laboratory and Region VIII will provide training to CRSC and State personnel on operations and applications of the ENVIROPOD.

2. The State of Utah and/or other requesting agencies, will cover costs of the aircraft, crew, and associated expenses.
3. CRSC and the State of Utah will coordinate all missions with EPA Region VIII.
4. EMSL-LV will provide all film processing for a one-year period.
5. The State of Utah and CRSC will prepare an evaluation report at completion of experiment.

PROVISIONS

1. Direct support will be provided by the EMSL-LV and Region VIII. This will include necessary training, film processing, and camera maintenance.
2. The activities conducted through this agreement can be terminated by one of the participants by providing written notice ninety (90) days prior to proposed termination date.
3. The State will be responsible for equipment, crews, public and private property in the event of accidents.
4. EPA is not responsible for any liability in the operation of the aircraft or the ENVIROPOD. This includes any legal action(s) that may arise in connection with the purpose for which the equipment is operated and/or deployed by the State of Utah.
5. The period of Memorandum of Understanding is March 1, 1983 through February 28, 1984.

AUTHORIZATION

1. Dr. Merrill Ridd, Director, Center for Remote Sensing and Cartography, University of Utah Research Institute, in cooperation with SPCO, will coordinate activities, including monitoring requirements, flight planning, funds, and program administration.
2. Mr. Gary A. Shelton of EPA will coordinate activities between the EPA Headquarters and Region VIII. Mr. Denis Nelson will coordinate those activities between CRSC/State, and the EPA Region VIII.

RESPONSIBILITIES

1. The Environmental Protection Agency will provide:
 - (a) a minimum of one ENVIROPOD with two cameras to the participating State on a loan basis;
 - (b) processing of film;
 - (c) observer training in installation, operation, and camera maintenance.
2. The State of Utah, or the requesting agency, will provide for:
 - (a) insurance;
 - (b) fuel;

- (c) aircraft;
- (d) crews.

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3. CRSC will actively promote the use of ENVIROPOD among State, federal, and local agencies, and demonstrate its utility as a part of its on-going NASA-sponsored outreach effort. In addition, with appropriate funding from the cooperating agencies, CRSC will provide:

- (a) overall program coordination and communication;
- (b) project planning consultation;
- (c) integrated project planning with all interested State, federal, and local agencies.

CRSC will also provide, at cost, photointerpretation and resource analysis/planning services as requested on a project basis.

AUTHORITY

This agreement is entered under the authority of the Intergovernmental Cooperation Act.

Wm. S. Partridge, President
University of Utah Research Institute

Date

Steven J. Durham,
Regional Administrator-Region VII
U.S. Environmental Protection Agency

Date

Glenn E. Scheitzer, Director
Environmental Monitoring Systems Laboratory
U.S. Environmental Protection Agency

Date

Marthe Dyer, State Planning Coordinator
State of Utah

Date

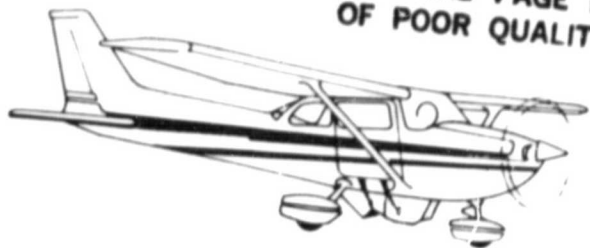
Eugene Findlay, Director
Utah Division of Finance

Date

David L. Wilkinson, Attorney General
State of Utah

Date

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Nearly 100 years ago George Eastman introduced photography to the public with the phrase,

"You press the button — We do the rest."

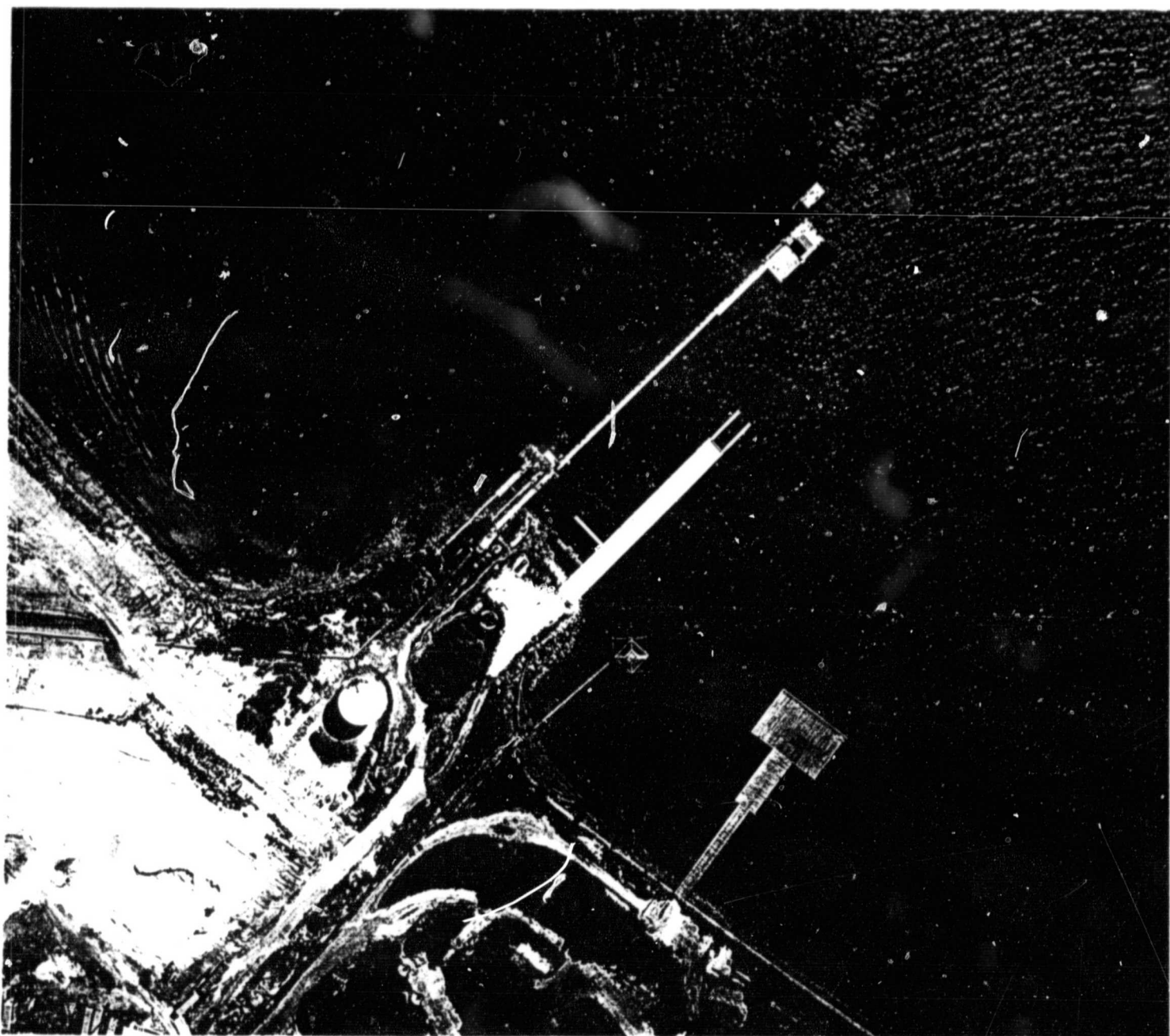
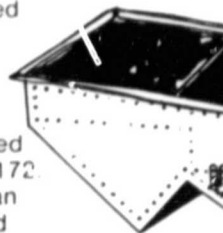
SEEING IS BELIEVING

Aerial imagery is an ideal medium for documenting the location, size and impact of pollution sources. But until now, obtaining these images for many applications was difficult and expensive. With the support of the EPA's Environmental Monitoring and Support Laboratory in Las Vegas, Nev. and Warrenton, Va., color or black and white images of your area can be obtained at reasonable cost. The key is Enviro-Pod, a two-camera observation system which can be conveniently attached to a Cessna 172. Film processing is available and interpretation of the images can be provided through Agency channels.

USING ENVIRO-POD

Agency offices having Enviro-Pods with loaded cameras must arrange for a pilot and a Cessna 172.

After the mission is complete, the cameras can be shipped to an Environmental Monitoring and



Outfalls into Chesapeake Bay

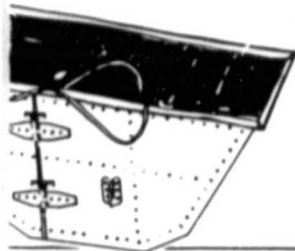
Support Laboratory (EMSL) photo lab for film processing and interpretation. Advanced scheduling arrangements made with the processing center will ensure prompt service.

At the processing center, the cameras will be reloaded with film and returned to the user for further image acquisition.

The processing center will process, title, plot and interpret the film in accordance with the user's mission requirements.

Applications envisioned for the Enviro-Pod include:

1. Routine compliance monitoring and quick response to environmental emergencies.
2. Oil and hazardous materials spill detection, as well as reconnaissance of storage and containment.
3. Provision of certain imagery needed for environmental impact statements.
4. Support for enforcement actions.



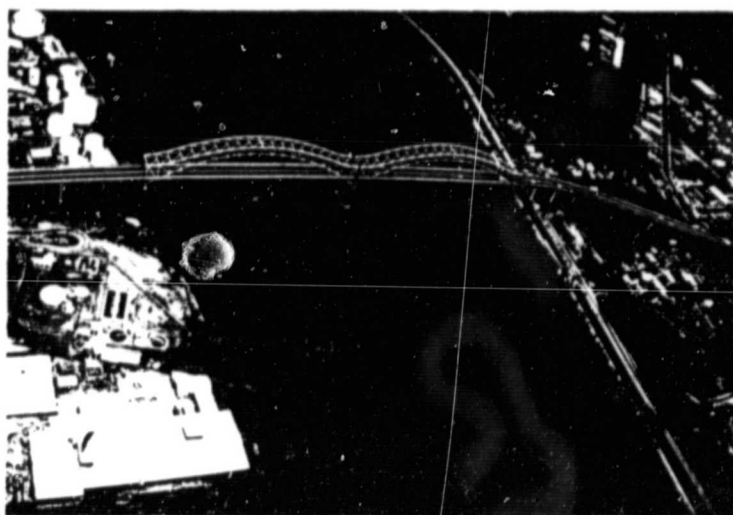
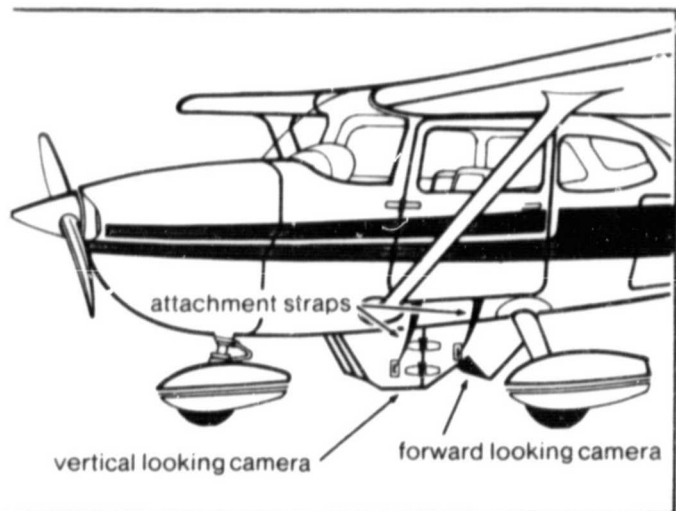
TRAINING AND INFORMATION

Enviro-Pod aerial imagery, like all remote sensing methods, can be considerably more valuable when the equipment operators are trained and experienced.

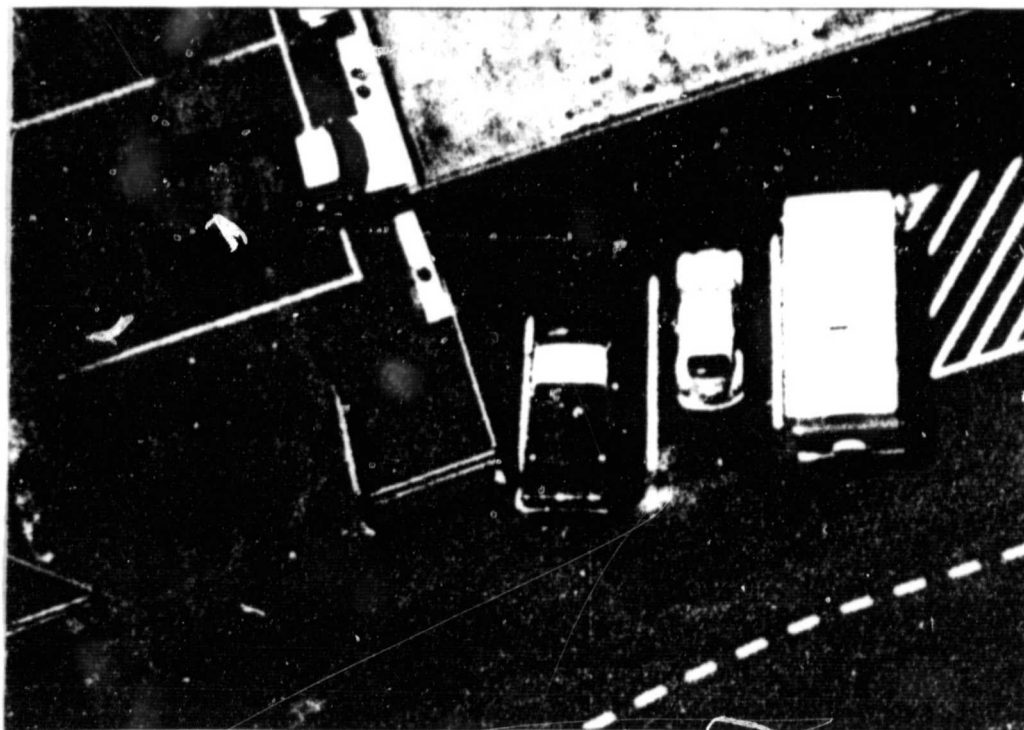
The Environmental Photographic Interpretation Center (EPIC) in Warrenton, Va., can train designated individuals from each Agency user office in the installation, maintenance and operation of Enviro-Pod. The EMSL, at Las Vegas or Warrenton, can provide information in the principles of remote sensing.

Enviro-Pod has been successfully demonstrated in Washington, D.C., Boston, Atlanta, Philadelphia and New York. A series of flights were conducted to test the unit's operation, demonstrate its potential value to EPA's Regional Offices and determine the kinds of environmental problems for which Enviro-Pod could be utilized.

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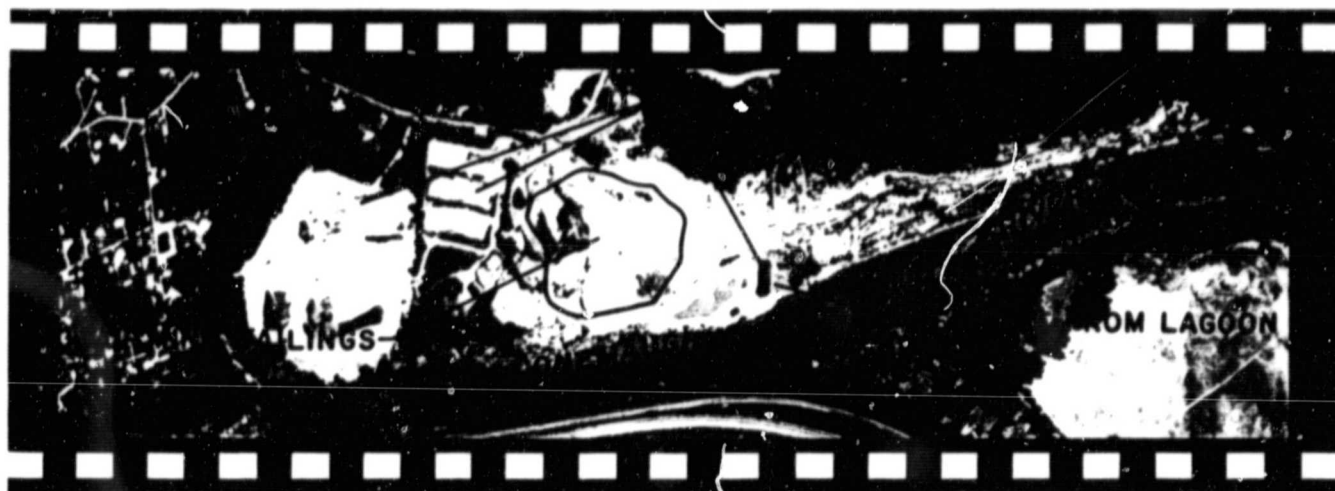
Color Infrared Photography showing Connecticut River using the forward oblique camera (film type 2443 with Wratten 21 filter).



System resolution capability as shown on this 1:1 and 40X enlargement.



Bethlehem Steel Plant Sparrows Point Maryland Vertical and forward oblique views



Enviro-Pod imagery with annotated overlay (actual negative size)

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TYPICAL COSTS

Operating costs to the user are minimized due to the technical support available from the Environmental Monitoring and Support Laboratory. The user must purchase only the Pod itself to get started (approximately \$5000). The cameras are provided by the Laboratory.

To examine the cost of using the Enviro-Pod system consider this typical mission for 1977. The area of interest is 100 miles from where the aircraft is based. The area to be covered will use a complete roll of color film (300 exposures @ \$88). The aircraft will be used for approximately three hours @ \$40/hour with pilot or \$25/hour if an EPA pilot is used. Film processing and printing at the Environmental Monitoring and Support Laboratory is estimated to be \$200. Therefore, aircraft without pilot is \$75, processing is \$200 and film is \$88, amounting to \$363 for the mission.

ENVIRO-POD DESIGN

The Pod uses two KA-85A panoramic cameras selected for their compactness, resolution and availability. The Pod is divided into two sections, each constructed of aluminum. The size and shape of the sections were designed to allow convenient transport as commercial airline luggage.

For flight the Pod is mated to the outer surface of a Cessna 172. Steel straps secure the Pod to the seat rails of the aircraft without interfering with door closure. The camera controls provide the option of automatic operation or individual exposures controlled by a switch. The Pod design can be adapted to accept other sensor systems such as television, thermal scanning and forward-looking infrared imaging as they are developed.

WHAT IS ENVIRO-POD?

A compact, self-contained, panoramic, two-camera reconnaissance system designed (and FAA approved) to be secured to a widely available aircraft (the Cessna 172). Enviro-Pod can provide vertical and forward looking color or black and white images of high resolution (on a scale of inches). With maintenance, film processing and image interpretation supplied by the Environmental Monitoring and Support Laboratory in Las Vegas, Nev. and Warrenton, Va., this high quality imagery is available quickly and at moderate cost.

SCALE VERSUS ACQUISITION COSTS

SCALE	AIRCRAFT ALTITUDE	SQ MI COVERED**	COST PER SQ MI	GROUND RESOLUTION	OBJECTS OBSERVED
1/1,000	250	1.0	\$363	0.06 ft	individual pipes
1/10,000	2,500	104	3.49	0.6 ft	outfalls, pipes
*1/20,000	5,000	415	0.87	1.2 ft	people, minor stacks, types of vehicles
1/40,000	10,000	1661	0.22	2.4 ft	industrial components
1/48,000	12,000	2392	0.15	3.0 ft	industry, major stacks, major outfalls

*Commercial rates for color aerial photographs are approximately \$2.00 per square mile at a scale of 1/20,000

**Assuming 50% overlap between adjoining images



For more information on the Enviro-Pod, call the director of the Remote Sensing Division 702-736-2969 (FTS 8-595-2969) or the chief of the Environmental Photographic Interpretation Center at 703-347-6224 (FTS 8-557-3110), or write to: Environmental Monitoring and Support Laboratory, Environmental Protection Agency, Las Vegas, Nev. 89114 or Warrenton, Va. 22186

MAPPING OF RIPARIAN HABITAT ON THE HUMBOLDT
RIVER, DEETH TO ELKO, NEVADA

CONTRACTING AGENCY: Nevada Department of Wildlife

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Marcus (Pete) Rawlings
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702-738-5332

CONTRACTOR: Center for Remote Sensing & Cartography
University of Utah Research Institute
420 Chipeta Way, Suite 90
Salt Lake City, UT 84108
A Nonprofit Organization

PROJECT LEADER: Merrill Ridd
801-581-8018

BEGINNING DATE: March 1, 1983 COMPLETION DATE: October 31, 1983

- OBJECTIVES:
1. Prepare U.S.G.S. topographic map overlays (1:24,000) of riparian habitat along the Humboldt River from Deeth to the confluence of the South Fork of the Humboldt River below Elko, Nevada, from color infrared photography.
 2. Provide observations regarding the effects of riparian habitat control efforts and record significant river features (i.e., rip-rap, diversions) based upon field investigations.
 3. For one selected study site (e.g., in the Elko West quadrangle), provide historical insight into the many questions relative to wildlife population changes through time as a result of habitat modifications of riparian systems through channelization and phreatophyte eradication. Some of these questions include:

- a) What new habitat characteristics occur in the area?
- b) What are the wildlife responses to those changes?
- c) What is the "persistence period" of the altered habitat (i.e., how long does it take for approximately original conditions to return)?
- d) Are there any "one way" changes in soil/vegetation/hydrologic characteristics that do not seem to resume original conditions?
- e) What are the changes in channel characteristics that occur with various phreatophyte and channel modification methods?
- f) What is the apparent short and long-term effects on aquatic wildlife habitat?
- g) What are the apparent long-term effects on channel and near-channel stability?

While precise answers to most of these questions would require calibrated monitoring through time, approximate answers can likely be obtained from careful analysis of historic photos, supported with field investigation and interviews. Cooperation from land owners/operators would be helpful.

PURPOSES:

- 1. Provide a basic spatially-oriented information base for wildlife population and habitat management along the Humboldt River.
- 2. Facilitate the development of Department policies and public awareness regarding proposals for and actions to carry out river channelization and phreatophyte control.
- 3. Facilitate the documentation of present river—habitat conditions and provide a vehicle for future analysis of habitat trends.
- 4. Explore the extent to which available color infrared photography will provide cost-effective information needed in terms of spatial and interpretive accuracy.
- 5. To reconstruct and determine the past and current trends (1949-1980) of a sample section of the Humboldt River riparian habitat and its assorted wildlife population.

STUDY AREA:

The zone of riparian habitat in and adjacent to the Humboldt River from Deeth to the confluence of the South Fork of the Humboldt River with the Humboldt River below Elko, Nevada. The following eight U.S.G.S. 7½ minute quadrangles (scale 1:24,000) cover the study area:

Deeth	Osino
Morgan Hill	Elko East
Halleck	Elko West
Ryndon	Hunter

FINAL PRODUCTS:

1. A clear overlay to each of the study area quadrangles noted above showing delineations of riparian habitat cover types and significant river alterations.
2. Technical report describing methods, results, and field observations.
3. The product from the historical evaluation portion of the investigation will be a series of 5 or 6 transparent overlays to the 7½ minute quadrangle selected, illustrating the spatial changes in environmental conditions, and a written report structured to respond to the questions raised in objective #3 as fully as possible.

MATERIALS NEEDED:

1. Large-Scale Photography:

BLM aerial mapping color infrared (CIR) photography flown April 1 to June 15, 1978; scale 1:24,000.
Estimated cost: \$310.

2. High Altitude Photography:

National High Altitude Program (NHAP) aerial mapping CIR photography flown in 1980; scale 1:58,000.
Estimated cost: \$84.

3. Department Photography:

It will be helpful to have access to small-frame (ca. 70mm) CIR photography flown by the State of Nevada, accessible to Department personnel (approximate scale: 1:20,000).

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4. Historical Evaluation Investigation Photography:

<u>Date</u>	<u>Time Increment</u>	<u>Form</u>	<u>Scale</u>	<u>Source</u>
Sept. 1949		B/W	1:20,000	TXPIC
	6			
Aug. 1955		B/W	1:23,000	USGS
	10			
Oct. 1965		B/W	1:15,799	BLM
	2			
Oct. 1967		B/W	1:15,799	BLM
	4			
Oct. 1971		CIR	1:55,098	NASASJ
	3			
1974		B/W	1:40,000	ASCS
	4			
1978		CIR	1:24,000	BLM
	2			
1980		CIR	1:58,000	ASCS

ANALYSIS:

Since accuracy both in photo interpretation and in map preparation depends upon effective integration of field information with photography, it will be necessary for field personnel from the Department's office in Elko to cooperate with CRSC in field efforts. Information regarding the riparian habitat and management history in the study area (available in Department files) will be useful and assistance of Department personnel in planning and performing field investigations will be important in this study. Department personnel will also need to work closely with CRSC in developing the map legend to meet their needs.

The map overlay will generally reflect conditions as of 1978, but field observations to be made in the spring and summer of 1983 and the 1980 NHAP photography will be used to update the maps.

CRSC plans to map land cover into the following primary units: willow, hay meadow, willow/hay meadow complexes, water, and upland vegetation. Where narrow strips of willow occur, linear symbols will be used on the overlay. To the extent the available remote sensing media will provide, additional delineations of cover types such as cattail marsh, rose, salt grass, and other important habitat types will be made. CRSC will also designate channelized areas and, where detectable, willow treatment areas.

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For the historical evaluation portion of the study, judicious selection of five or six dates of photography of an appropriate area of study should provide the foundation for a useful time-space analysis of management practices and environment (habitat) changes. Maps of changing characteristics will be prepared accordingly.

It is proposed that a study site be selected, such as in the Elko West 7½ minute quadrangle, to pursue the mapping of change since 1949 in the riparian conditions. The above eight questions will be used as a guide to investigation. All available archival information relevant to those questions will be sought, and that appropriate cooperating owners/operators be selected to provide local experiential information.